STUDIES ON BOREAL AGROMYZIDAE (DIPTERA). IX. *PHYTOMYZA* MINERS OF BORAGINACEAE IN NORTH AMERICA

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Four species of the Phytomyza symphyti *group are recorded as leaf-miners of Boraginaceae in northwestern North America, as follows:* Phytomyza mertensiae *Sehgal,* P. petiolaris *n. sp. (type-locality Walker Fork, Alaska),* P. ovalis *n. sp. (type-locality Lake Teslin, Yukon Territory) and* P. beringiana *n. sp. (type-locality Salcha River, Alaska). Revised keys are given to the males and leaf-mines of this group, as well as a discussion of phylogeny and host-plant relationships.*

Quatre espèces du groupe Phytomyza symphyti *sont signalées comme mineuses des feuilles des Boraginacées dans le nord-ouest d'Amérique du nord, tel que:* Phytomyza mertensiae *Sehgal,* P. petiolaris *n. sp. (localité-type Walker Fork, Alaska),* P. ovalis *n. sp. (localité-type Lac Teslin, Territoire de Yukon) et* P. beringiana *n. sp. (localité-type Rivière de Salcha, Alaska). Des clefs nouvelles sont pourvues pour les mâles et les mines de ce groupe, aussi qu'une discussion de la phylogenie et les relations avec les hôtes végétals.*

Folgende vier Arten der Phytomyza symphyti-*Gruppe werden als Blattminierer von Boraginaceae aus dem nordwestlichen Nordamerika besprochen:* Phytomyza mertensiae *Sehgal,* P. petiolaris *n. sp. (Fundort des Typus: Walker Fork, Alaska),* P. ovalis *n. sp. (Fundort des Typus: Lake Teslin, Yukon Territorium) und* P. beringiana *n. sp. (Fundort des Typus: Salcha River, Alaska). Neue Bestimmungstabellen zum Männchen und Blattminen für dieser Gruppe werden gegeben, sowie Erörterungen über Phylogenie und Wirtspflanzenbeziehungen.*

The European species of the *Phytomyza symphyti* group have been described and discussed in much detail by Nowakowski (1959), who treats this group of Boraginaceae-miners as a subgroup of the *Phytomyza obscura* group *sensu lato* (the other subgroups being miners of Labiatae). In that paper Nowakowski distinguished four European species of the *P. symphyti* group: *P. lithospermi* Now., *P. pulmonariae* Now., *P. symphyti* Hendel and *P. myosotica* Now. I am satisfied on the basis of my European material that Nowakowski's species concepts are correct. Very recently, Beiger (1975) has described a fifth European species, *P. nowakowskiana* Beiger, so far known only from south-east Poland. Since no further revision of the European species seems needed, I describe only the North American species in this paper. My rearings on this continent have yielded three undescribed species, in addition to the single species previously described by Sehgal (1971).

The holotypes of the new species described in this paper will be deposited in the Canadian National Collection (Ottawa). See the first paper in this series (Griffiths, 1972) for explanation of terms and abbreviations.

PHYLOGENY AND HOST-PLANT RELATIONSHIPS

Nowakowski (1959) has postulated the phylogenetic relationships between the European species of the *Phytomyza symphyti* group, based on interpreting as plesiomorphous the condition of the posterior larval spiracles of *P. lithospermi* Now. (in third-instar larva and puparium with 10-14 bulbs in oval ellipse). Hence he considered that species to be the sister-group of the

three remaining European species (*P. pulmonariae* Now., *P. myosotica* Now. and *P. symphyti* Hendel), to which the newly described *P. nowakowskiana* Beiger must now be added; these all have narrow two-horned posterior spiracles (compare Fig. 17). However, three of the North American species described below (*P. ovalis* n. sp., *P. petiolaris* n. sp. and *P. mertensiae* Sehgal) also have oval posterior spiracles like *P. lithospermi* (compare Fig. 18). Whether or not these four species are monophyletic is not clear. It would be incorrect to group them together merely on the basis of their similar spiracles (symplesiomorphy). So the only firm hypothesis which I draw from the distribution of spiracle types is that the species with narrow two-horned posterior spiracles (the four European species listed above, together with *P. beringiana* n. sp.) form a monophyletic group. The range of variation in the number of spiracular bulbs in species of this group forms the following series (Variabilitätsreihe), based on my own data added to that published by Nowakowski (1959) and Beiger (1975).

Species	Number of spiracular bulbs in 3rd instar larva and puparium		Possible Monophyletic Groups
	Anterior Spiracles	Posterior Spiracles	
P. pulmonariae Now.	10	10 - 14	
P. beringiana n. sp.	15 - 18	15 - 18	
P. myosotica Now.	15 - 18	15 - 19	
P. nowakowskiana Beiger	13 - 15	18 - 23 (mostly 19-21)	
P. symphyti Hendel	17 - 19	21 - 27 (mostly 22-25)	

Apart from variation in the form of the larval spiracles, the species of the *P. symphyti* group also differ from one another in respect of details of their aedeagal structure. These differences are of high diagnostic importance, but scarcely help the phylogenetic analysis as the direction of change is not known. In general, it should be recognized that in dealing with complexes of species differentiated mainly by proportional or meristic characters, we are near the limits of resolution of phylogenetic analyses based on visible form alone. For this reason I prefer to be more cautious than Nowakowski, and doubt whether the existing information warrants asserting more than two phylogenetic hypotheses, namely: (i) that the *P. symphyti* group as a whole is monophyletic, and (ii) that included within this group is a monophyletic group of five species (as above) with narrow two-horned posterior larval spiracles. Within the latter group, the simplest interpretation of the variation in the range of posterior spiracular bulb numbers (as a single series of increasing numbers) suggests two further monophyletic groups, as indicated in the right-hand column of the above table. But too much reliance should not be placed on these suggested groupings, as the existing analysis provides no additional interpreted character sequences against which they can be checked.

Nowakowski interprets the differentiation of the *P. symphyti* group as primarily the result of food-plant specialization (ecological isolation). His data indicated one species *(P. lithospermi)* confined to the Lithospermeae, one *(P. myosotica)* to the Myosotideae, and two *(P. pulmonariae* and *P. symphyti)* to the Anchuseae. Only on *Symphytum* (Anchuseae) was an overlap in host range suggested. Nowakowski reported both *P. pulmonariae* and *P. symphyti* on this plant genus (see also the note by Hering, 1963), and Beiger's (1975) new species *P. nowakowskiana* is also a *Symphytum*-miner.

It now seems confirmed that food-plant specialization cannot have been the sole cause of differentiation. The four North American species treated in this paper all have the same main

host, *Mertensia paniculata* (Ait.), which is the only large-leaved member of the Boraginaceae available through much of the boreal forest in northwestern North America. Interestingly, there is a topographical vicariance between *P. petiolaris* n. sp. and the other three species, the former being the only species of this group whose larvae feed in the petiole and midrib of the leaf. In Europe the host vicariance reported by Nowakowski is certainly real, although an additional overlap has since come to light (both *P. myosotica* and *P. pulmonariae* on *Myosotis*). I have received a male of *P. pulmonariae* bred from larva 1.vi.66 on *Myosotis sylvatica* (Ehrh.), Mühlhausen (Stadtwald), Thuringia, Germany, emerged 12.vi.66, leg. H. Buhr (no. 2818). My view is that the differentiation of the *P. symphyti* group has been the result of a complex interaction of geographical and ecological isolation, and that we should not overemphasize the importance of one of these factors at the expense of the other. It seems premature to hypothesize about the details of this interaction in the absence of information on the Asian representatives of this group.

DIAGNOSIS

The keys which follow are partly based on that given by Nowakowski (1959: 194). Adults of the *Phytomyza symphyti* group can be identified only by study of the male aedeagus. Since I have no larval preparations but only puparia of the North American species, I have omitted Nowakowski's distinction between the presence or absence of a group of spinules (Warzengruppe) on the larval head. This cannot be reliably determined in puparia. I have also omitted his distinction between the presence or absence of the prothoracic and mesothoracic spinule bands. This distinction requires further study in larval preparations. At least the mesothoracic band is present dorsally in some of my puparia of *P. myosotica* Now., a species which Nowakowski characterizes as lacking these bands.

The larvae of various *Agromyza* species also mine the leaves of Boraginaceae. These may be distinguished from larvae of the *Phytomyza* and *Chromatomyia* species included in the keys below by their larger size and three-bulbed posterior spiracles.

Key to males of *Phytomyza symphyti* group

1 Lateral sclerites of medial lobe of aedeagus tapering apically, well separated from one another (Nowakowski, 1959, Fig. 14). Europe . . *P. lithospermi* Nowakowski

1' Lateral sclerites of medial lobe expanded in posteroventral view, turned inwards and more or less fused with one another apically 2

2 (1') Pigmented lateral angles on either side of terminal processes of aedeagus (Fig. 10). Alaska . . . . . *P. beringiana* n. sp.

2' Lateral angles not pigmented 3

3 (2') Pigmented processes extending from apical corners of lateral sclerites of medial lobe (Fig. 9). North America . . . . . *P. mertensiae* Sehgal

3' Lateral sclerites of medial lobe without pigmented processes 4

4 (3') Sclerotization of distal section of aedeagus (mesophallus) of rather uniform width in lateral view (Fig. 3), with paired terminal processes well separated (Fig. 1); lateral sclerites of medial lobe shorter than paramesophalli. North America . . . . . *P. ovalis* n. sp.

4' Sclerotization of distal section in lateral view much narrower posteriorly than anteriorly 5

5 (4') Sclerotization of distal section weakly S-shaped in lateral view (turned downwards basally), with terminal processes contiguous; lateral sclerites of medial lobe shorter than or about as long as paramesophalli (Nowakowski, 1959, Fig. 17). Europe . . . . . *P. myosotica* Nowakowski

5' Sclerotization of distal section more or less straight, not turned downwards basally 6

6 (5') Terminal processes of distal section contiguous or narrowly separated; lateral sclerites of medial lobe obviously longer than paramesophalli (Nowakowski, 1959, Fig. 16). Europe ..... *P. pulmonariae* Nowakowski

6' Terminal processes of distal section well separated 7

7 (6') Sclerotization of distal section (mesophallus) narrow with strongly sinuate dorsal margin in lateral view; lateral sclerites of medial lobe appearing much expanded apically in lateral view (Nowakowski, 1959, Fig. 20). Europe ..... *P. symphyti* Hendel

7' Sclerotization of distal section wider in lateral view..... 8

8 (7') Aedeagus as figured by Beiger (1975, Fig. 1), with lateral sclerites of medial lobe extending almost from apex of basal sclerites. Europe ..... *P. nowakowskiana* Beiger

8' Aedeagus as Fig. 5-7, with lateral sclerites of medial lobe well separated from apex of basal sclerites. North America ..... *P. petiolaris* n. sp.

Key to *Phytomyza* and *Chromatomyia* mines on Boraginaceae

1 Puparia formed inside leaf, with anterior spiracles turned downwards, projecting through epidermis. Mines narrowly linear throughout ..... *Chromatomyia horticola* (Goureau)

This polyphagous old-world species has been reported from *Heliotropium, Cynoglossum, Omphalodes, Trichodesma, Caccinia, Lappula, Asperugo, Anchusa, Lycopsis, Nonea, Pulmonaria, Symphytum, Borago, Lithospermum, Myosotis, Cerinthe, Podonosma* and *Echium* (Griffiths, 1967).

1' Puparia formed outside leaf, or, if inside, anterior spiracles not turned downwards and semicircular exit slit cut by larva before puparium formation. Mines at least partly blotchy ..... (*Phytomyza symphyti* group) 2

2 (1') Posterior spiracles of third instar larva and puparium oval (Fig. 18)..... 3

2' Posterior spiracles of third instar larva and puparium two-horned, with bulbs arranged in narrow ellipse (Fig. 17)..... 5

3 (2) Larva feeding partly in petiole and midrib of leaf (Fig. 14). North America. On *Mertensia* ..... *Phytomyza petiolaris* n. sp.

3' Larva feeding solely on parenchyma of leaf, avoiding petiole and basal part of midrib 4

4 (3') Europe. On *Lithospermum* ..... *Phytomyza lithospermi* Nowakowski

4' North America. On *Mertensia, Myosotis* and *Hackelia* .. *Phytomyza ovalis* n. sp. ..... or *Phytomyza mertensiae* Sehgal

5 (2') Posterior spiracles of third instar larva and puparium with 10-14 bulbs. Puparia mostly with dorsal swelling on mesothorax. Europe. On *Pulmonaria, Symphytum* and *Myosotis* ..... *Phytomyza pulmonariae* Nowakowski

5' Posterior spiracles of third instar larva and puparium with more numerous bulbs 6

6 (5') Puparia mostly with dorsal swelling on mesothorax. Europe. On *Symphytum*.. 7

6' Puparia without dorsal swelling on mesothorax. Posterior spiracles of third instar larva and puparium with 15-19 bulbs 8

7 (6) Posterior spiracles of third instar larva and puparium with 21-27 bulbs (mostly 22-25) ..... *Phytomyza symphyti* Hendel

7' Posterior spiracles of third instar larva and puparium with 18-23 bulbs (mostly 19-21) ..... *Phytomyza nowakowskiana* Beiger

8 (6') Puparia normally formed inside leaf. Europe. On *Myosotis* . . . . . *Phytomyza myosotica* Nowakowski

8' Puparia formed outside leaf. Alaska. On *Mertensia*. . *Phytomyza beringiana* n. sp.

TREATMENT OF SPECIES

Phytomyza ovalis new species

Adult. – Head with orbits not or scarcely projecting above eye in lateral view; genae in middle 0.2-0.25 times eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus about 1½ times width of eye. Ors directed posteriorly, ori directed inwardly; posterior ors 0.5-0.9 times as long as anterior ors, about equidistant between anterior ors and vti; anterior ori variably developed, 0.3-0.7 times as long as posterior ori (with additional third pair of ori in female from Summit Lake Pass); orbital setulae more or less one-rowed. Peristomal margin with vibrissa and 3-5 upcurved peristomal setulae. Third antennal article rounded distally, about as long as high, with short pubescence.

3 + 1 dc; acr numerous, in 4-7 rows anteriorly; presutural ia numerous; 6-11 postsutural ia; inner pa 1/3 to 1/2 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.3-2.8. Wing length: ♂, 2.1-2.2 mm; ♀, 2.35-2.5 mm.

Colour largely dark. Centre of frons dark brown to black; genae orange-brown to dark brown. Labella yellow. Thorax largely shining black, finely grey-dusted, with contrasting white stripes along notopleural and mesopleural sutures. Wing base and squamae white, latter with dark fringe. Coxae black; trochanters and femora largely brown to black; tips of front femora and bases of front tibiae bright yellow; tips of other femora yellow-brown; front tibiae and tarsi largely yellow to yellow-brown; other tibiae and tarsi yellow-brown to brown. Abdomen largely brown, but with contrasting whitish stripes on sides along margins of terga. Basal cone of ovipositor (♀) grey-dusted on about basal half.

Eighth sternum of male postabdomen narrowly separated from 6th tergum or more or less fused along distinct suture line, with narrow lateral extensions to sides of venter. Telomeres represented by densely setulose apical lobes of periandrium, not delimited by suture. Epiphallus with apical thorn. Pregonites not extending ventrally; hypandrial arms broad in ventral view. Aedeagus as Fig. 1-3; basal sclerites much expanded; ejaculatory duct slightly pigmented within basal section; central sclerite of medial lobe ("hypophallus" Nowakowski) well developed; lateral sclerites of medial lobe distinctly shorter than paramesophalli, expanded in posteroventral view, more or less fused apically below central sclerite where their pigmentation is weaker than at sides; cylindrical sclerotization of distal section (mesophallus) of rather uniform width in lateral view, with short ventral crest (Kamm), with paired terminal processes well separated and sinuate in ventral view. Ejaculatory apodeme as Fig. 4, large, slender at base, much expanded distally; ejaculatory bulb with pair of pigmented lateral tubercles; ejaculatory duct leading from ejaculatory bulb shortly pigmented.

Puparium and third instar larva. – Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles two-horned, with 13-15 bulbs; posterior spiracles (Fig. 18) oval, with 13-20 bulbs in oval (nearly circular) open ellipse. Puparia varying from yellow to dark red-brown, 1.8-2.0 mm long, without dorsal swelling on mesothorax.

Mine. – Larvae leaf-miners on *Mertensia, Myosotis* and *Hackelia.* Mine (Fig. 15) in leaf blade, in some cases with initial slender channel on upper or lower surface, later broadly linear or blotchy and in all cases on upper surface, on *Mertensia* and *Myosotis* appearing greenish brown in reflected light due to presence of feeding debris in fine herring-bone pattern (but mines on

Hackelia more whitish without conspicuous feeding debris); faeces irregularly deposited as large particles or in strips; larvae leaving leaf through semi circular slit on lower surface before puparium formation.

Initial linear channels can be seen clearly in mines from the type locality, but cannot be traced in some of the other mines. It is not clear whether this is due to variation in larval habit, or to destruction of the initial channels by later feeding.

Types. – Holotype ♂, 2 ♀♀ paratypes from larvae 31.viii-1.ix.69 on *Mertensia paniculata* (Ait.), near East shore of Lake Teslin (10 mile Creek; 60°14′N, 132°55′W), Yukon Territory, emerged 11-20.v.70, leg. G. C. D. Griffiths. 1 ♂ paratype from larva 15-18.vii.72 on *Mertensia paniculata* (Ait.), near S end Kluane Lake (4000-4500 feet elevation), Yukon Territory, emerged 11.v.73, leg. G. C. D. Griffiths; 1 ♂ paratype from larva 18.vii.72 on *Myosotis alpestris* F. W. Schmidt subsp. *asiatica* Vestergr., same locality (Slims Tundra at 4000 feet elevation), emerged 10.v.73, leg. G. C. D. Griffiths. 1 ♀ paratype from larva 5.viii.70 on *Mertensia paniculata* (Ait.), Summit Lake Pass (4500 feet elevation; Alaska Highway mile 392), British Columbia, emerged 10.v.71, leg. G. C. D. Griffiths. 1 ♂ 1 ♀ paratypes from larvae 19.vi.71 on *Hackelia americana* (A. Gray), Elk Island National Park (Elk Island in Astotin Lake), Alberta, emerged 9-10.vii.71, leg. G. C. D. Griffiths.

Remarks. – The name *ovalis* ("oval") refers to the shape of the posterior larval (and puparial) spiracles. Puparia of the next two species (*P. petiolaris* and *P. mertensiae*) have spiracles of the same type, and no constant differences from *P. ovalis* have been noted. However, it is likely that studies of the mouthparts in larval preparations will reveal differences in the case of *P. petiolaris* in view of the different feeding habit of the larvae.

The breeding data suggest that *P. ovalis* is bivoltine in Central Alberta, but probably univoltine further North.

Phytomyza petiolaris new species

Adult. – As described for *P. ovalis,* except as follows.

Frons at level of front ocellus 1.5-1.75 times width of eye. Posterior ors 0.7 times to almost as long as anterior ors (but absent on one side in one female); anterior ori weak in all specimens, at most half as long as posterior ori. Acr in 4-5 rows anteriorly; 7-9 postsutural ia; inner pa 1/4 to 1/3 as long as outer pa. Costal ratio mg_2/mg_4 2.95-3.1. Wing length: ♂, 2.15 mm; ♀, 2.4 mm.

Squamal fringe ochreous to brown. Tips of middle and hind femora yellow to yellow-brown; front tibiae and tarsi largely yellow-brown; other tibiae and tarsi yellow-brown to brown.

Aedeagus as Fig. 5-7; lateral sclerites of medial lobe as long as or only slightly shorter than paramesophalli, uniformly pigmented and well defined in posteroventral view; cylindrical sclerotization of distal section (mesophallus) much wider anteriorly than posteriorly in lateral view, with long ventral crest (Kamm). Ejaculatory apodeme as Fig. 8, broader at base; tubercles of ejaculatory bulb very large.

Puparium and third instar larva. – Very similar to those of *P. ovalis.* Anterior spiracles two-horned, with 10-13 bulbs; posterior spiracles oval, with 11-14 bulbs in oval (nearly circular) open ellipse (compare Fig. 18). Puparia yellow to golden yellow, 1.9-2.0 mm long, without dorsal swelling on mesothorax.

Mine. – Larvae leaf-miners on *Mertensia.* Mine (Fig. 14) partly in petiole and midrib of leaf, with broad channels radiating into parenchyma, largely on upper surface, appearing greenish white or greenish brown in reflected light (with feeding debris forming fine herring-bone pattern in some mines, apparently absent in others); faeces mostly deposited in conspicuous bands in channels in parenchyma; larvae leaving leaf before puparium formation through semicircular

slit at end of inconspicuous terminal channel without faeces in parenchyma on lower surface.

Types. – Holotype ♂, 1 ♂ 2 ♀♀ paratypes from larvae 2-3.viii.68 on *Mertensia paniculata* (Ait.), Walker Fork (64°4′N, 141°38′W), Alaska, emerged 12.v.69, leg. G. C. D. Griffiths.

Remarks. – I have also found empty mines of this species in August near the East shore of Lake Teslin (Yukon Territory), in Summit Lake Pass at 4200 feet elevation (Alaska Highway mile 392; British Columbia) and in Whitemud Creek in the City of Edmonton (Alberta). It is probably univoltine, since the mines have not been found before August.

This is the only known species of the *P. symphyti* group whose larvae feed in the petiole and basal part of the midrib of the leaf.

Phytomyza mertensiae Sehgal 1971

Phytomyza mertensiae Sehgal. Sehgal, 1971: 369. Holotype ♂, Edmonton (Alberta), in Canadian National Collection, Ottawa.

Adult. – See Sehgal's (1971) description, which indicates the following differences from *P. ovalis.*

Frons at level of front ocellus about 2½ times width of eye. Acr in 4 irregular rows. Costal ratio mg_2/mg_4 2.8. Wing length about 2.0 mm (both sexes).

Squamal fringe brown. Tibiae and tarsi dark brown.

Aedeagus as Fig. 9 and Sehgal's Fig. 110-111; lateral sclerites of medial lobe uniformly pigmented and well defined in posteroventral view, with pigmented processes extending from their apical corners, about as long (excluding processes) as paramesophalli; cylindrical sclerotization of distal section (mesophallus) relatively short, only about twice as long as terminal processes, distinctly wider anteriorly than posteriorly in lateral view, with long ventral crest (Kamm). Ejaculatory apodeme as Sehgal's Fig. 112, broader at base; ejaculatory bulb with pigmented lateral tubercles as shown in that figure (the statement "bulb . . . membranous" in Sehgal's text being presumably a lapsus).

Puparium and third instar larva. – Very similar to those of *P. ovalis.* Puparium of holotype pale yellow, 1.85 mm long, with oval posterior spiracles (compare Fig. 18) bearing 15-18 bulbs in oval open ellipse; anterior spiracles lost.

Mine. – Larvae leaf-miners on *Mertensia,* forming linear mines according to Sehgal (1971) (presumably broadly linear as in other species of the *P. symphyti* group). I have not seen any specimen of the mines. The information given by Sehgal is insufficient to determine whether they can be reliably separated from mines of *P. ovalis* and *P. beringiana.*

Material examined. – Holotype ♂ from larva 10.ix.66 on *Mertensia paniculata* (Ait.), Edmonton (Whitemud Creek), Alberta, emerged 10.iii.67 (forced), leg. V. K. Sehgal.

Remarks. – The known material of this species remains that stated in Sehgal's (1971) original description, a bred pair (holotype ♂ and paratype ♀) and a male paratype caught at the same locality on 8.vi.67. Additional material is needed to clarify whether the mines and puparia can be distinguished from those of *P. ovalis.*

Phytomyza beringiana new species

Adult. – As described for *P. ovalis,* except as follows.

Frons at level of front ocellus 1½-2 times width of eye. Posterior ors variably developed, 0.65-0.75 times as long as anterior ors in two specimens, but short (on one side) or absent (on the other) in paratype male; anterior ori 0.3-0.7 times as long as posterior ori. 3-4 upcurved peristomal setulae. Acr in 4-5 rows anteriorly; 2-6 postsutural ia; inner pa 1/4 to 1/3 as long as outer pa. Costal ratio mg_2/mg_4 2.15-2.5. Wing length: ♂, 1.8-1.85 mm; ♀, 1.85 mm.

Squamal fringe yellow to pale brown. Front tibiae and tarsi largely yellow-brown; other tibiae and tarsi brown.

Aedeagus as Fig. 10-12; central sclerite of medial lobe weakly developed; lateral sclerites of medial lobe only slightly shorter than paramesophalli, much expanded in posteroventral view; cylindrical sclerotization of distal section (mesophallus) much wider anteriorly than posteriorly in lateral view, with slightly longer ventral crest (Kamm), with paired terminal processes closely approximated or contiguous in ventral view; pigmented lateral angles on either side of these terminal processes (Fig. 10). Ejaculatory apodeme as Fig. 13.

Puparium and third instar larva. – Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles two-horned (with horns slightly longer than in *P. ovalis* and *P. petiolaris*), with 15-18 bulbs; posterior spiracles (Fig. 17) distinctly two-horned, with 15-18 bulbs in narrow, widely open ellipse. Puparia golden yellow, 1.6-1.7 mm long, without dorsal swelling on mesothorax.

Mine. – Larvae leaf-miners on *Mertensia.* Mine (Fig. 16) in leaf blade, confined to upper surface, initially stellate (radiating from oviposition site), later becoming blotchy or with broad linear channels (similar to mature mine of *P. ovalis*), appearing greenish white or greenish brown in reflected light (with feeding debris forming fine herring-bone pattern in some mines, apparently absent in others); faeces irregularly deposited as large particles or in strips; larvae leaving leaf through semicircular slit on lower surface before puparium formation.

Types. – Holotype ♂, 1 ♂ 1 ♀ paratypes from larvae 12-14.vii.68 on *Mertensia paniculata* (Ait.) in poplar forest at Salcha River crossing of Richardson Highway (64°29′N, 146°54′W), Alaska, emerged 26.x.-18.xi.68 (forced), leg G. C. D. Griffiths.

Remarks. – This species is doubtless univoltine in nature; emergence of the flies in the late autumn of 1968 was due to delay in my obtaining outdoor storage facilities. It is so far the only confirmed North American species in which the posterior larval (and puparial) spiracles are of the narrow two-horned type. The most similar European species is *P. myosotica* Nowakowski, which differs from *P. beringiana* most clearly in respect of details of the distal section of the aedeagus (pigmented lateral angles absent; cylindrical sclerotization turned downwards basally).

I have two additional North American females with the posterior puparial spiracles as in *P. beringiana.* These are larger (wing length 2.25 mm and 2.4 mm) than the female in the type series of *P. beringiana*, and I cannot determine whether they are conspecific until they can be associated with males. Their data are as follows:

1 ♀ from larva 15-18.vii.72 on *Mertensia paniculata* (Ait.), near S end Kluane Lake (4000-4500 feet elevation), Yukon Territory, emerged 7.v.73, leg. G. C. D. Griffiths; 1 ♀ from larva 18.vii.72 on *Myosotis alpestris* F. W. Schmidt subsp. *asiatica* Vestergr., same locality (Slims Tundra at 4000 feet elevation), emerged 8.v.73, leg. G. C. D. Griffiths.

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REFERENCES

Beiger, M. 1975. Beitrag zur Kenntnis der minierenden Insekten Südostpolens. IV. Eine neue Art aus der Gruppe der *Phytomyza symphyti* Hd. (Diptera, Agromyzidae). Polskie Pismo entomologiczne 45: 133-139.

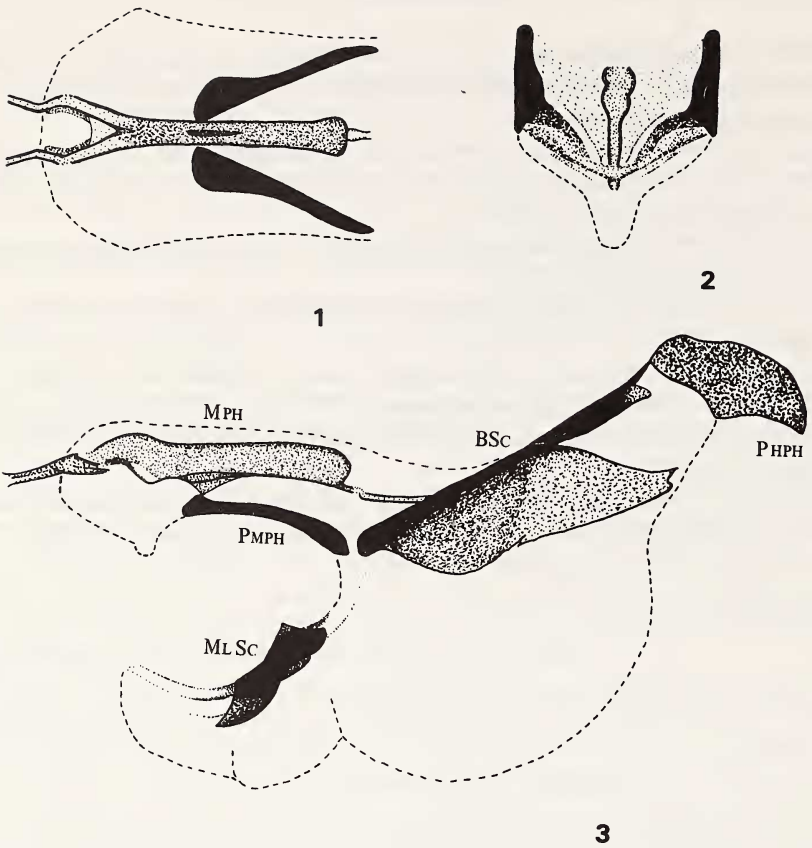
Griffiths, G. C. D. 1967. Revision of the *Phytomyza syngenesiae* group (Diptera, Agromyzidae), including species hitherto known as "*Phytomyza atricornis* Meigen". Stuttgarter Beiträge zur Naturkunde Number 177. 28 pp.

Griffiths, G. C. D. 1972. Studies on boreal Agromyzidae. I. *Phytomyza* miners on Saxifragaceae. Quaestiones entomologicae 8: 67-80.

Hering, E. M. 1963. Neue Blattminen-Studien III (Dipt., Lep.). Deutsche entomologische Zeitschrift 10: 221-250.

Nowakowski, J. T. 1959. Studien über Minierfliegen (Dipt. Agromyzidae). 3. Revision der in Labiaten und Boraginaceen minierenden Arten aus der Gruppe der *Phytomyza obscura* Hend., mit einem Beitrag zur Kenntnis ihrer Hymenopteren-Parasiten. Deutsche entomologische Zeitschrift 6: 185-229.

Sehgal, V. K. 1971. A taxonomic survey of the Agromyzidae (Diptera) of Alberta, Canada, with observations on host-plant relationships. Quaestiones entomologicae 7: 291-405.



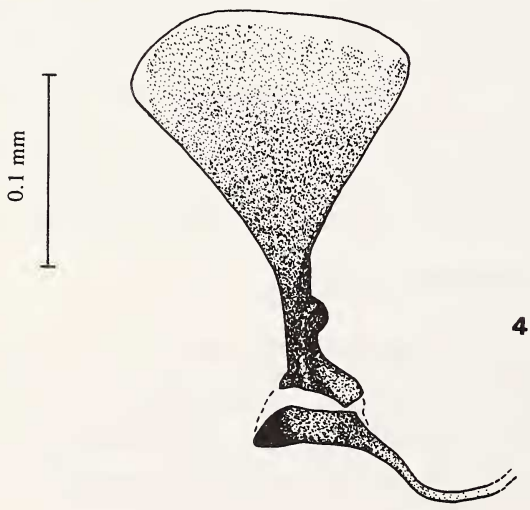


Fig. 1-4. *Phytomyza ovalis* n. sp., holotype ♂ : 1, distal section of aedeagus in ventral view; 2, medial lobe of aedeagus in ± posteroventral view; 3, aedeagus in lateral view (BSc basal sclerites, ML Sc sclerites of medial lobe, MPH mesophallus, PHPH phallophore, PMPH paramesophallus); 4, ejaculatory apodeme.

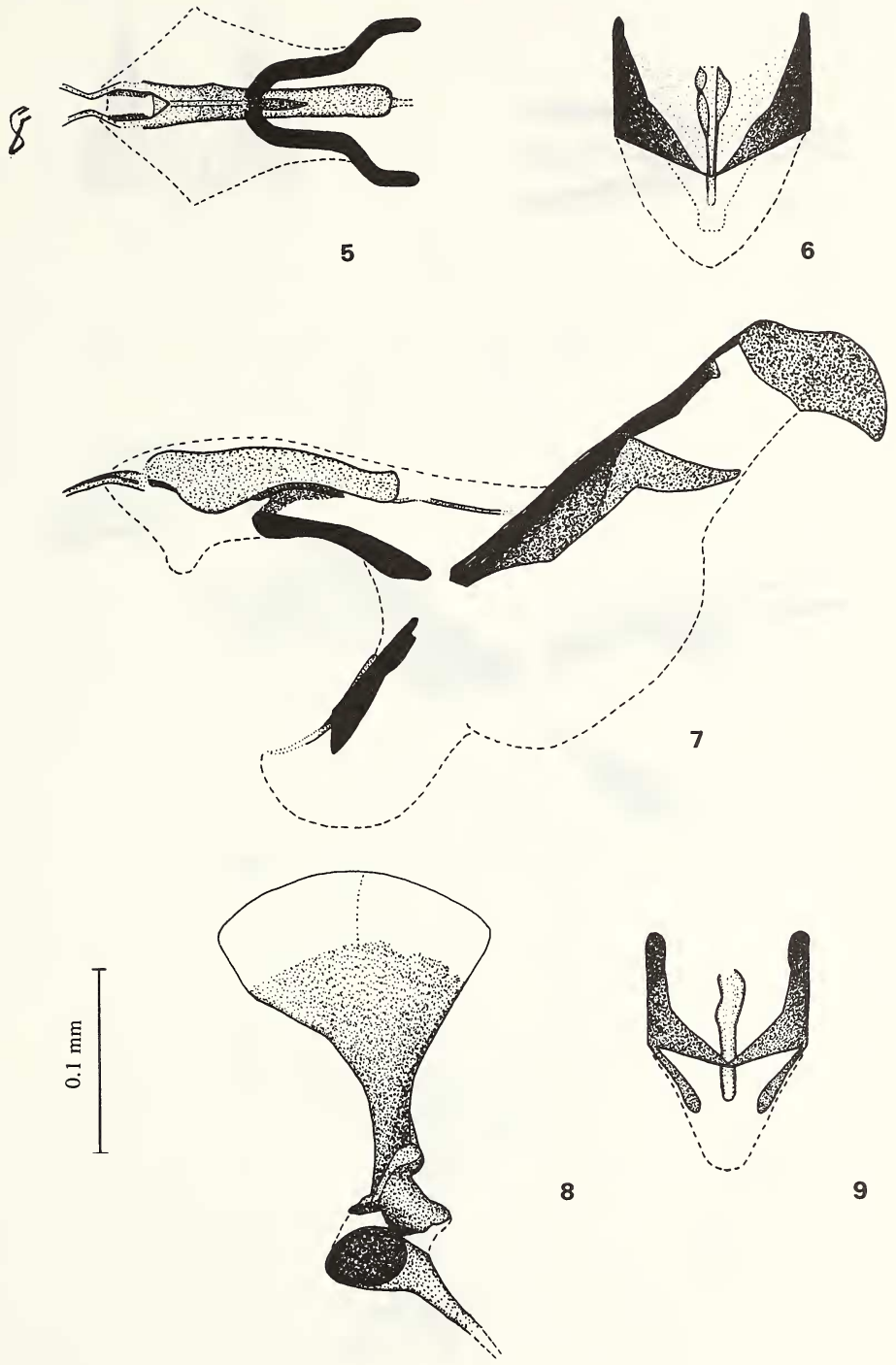
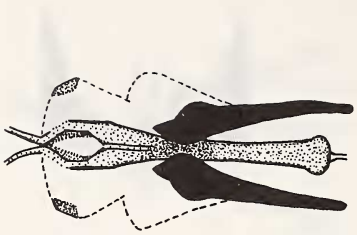


Fig. 5-8. *Phytomyza petiolaris* n. sp., holotype ♂ : 5, distal section of aedeagus in ventral view; 6, medial lobe of aedeagus in ± posteroventral view; 7, aedeagus in lateral view; 8, ejaculatory apodeme. Fig. 9. *Phytomyza mertensiae* Sehgal (holotype ♂), medial lobe of aedeagus in ± posteroventral view.



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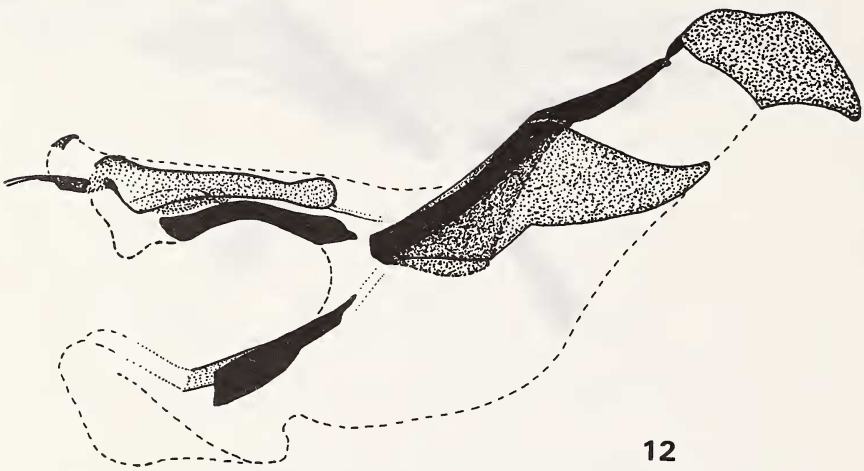

12

0.1 mm

13

Fig. 10-13. *Phytomyza beringiana* n. sp., holotype ♂ : 10, distal section of aedeagus in ventral view; 11, medial lobe of aedeagus in ± posteroventral view; 12, aedeagus in lateral view; 13, ejaculatory apodeme.

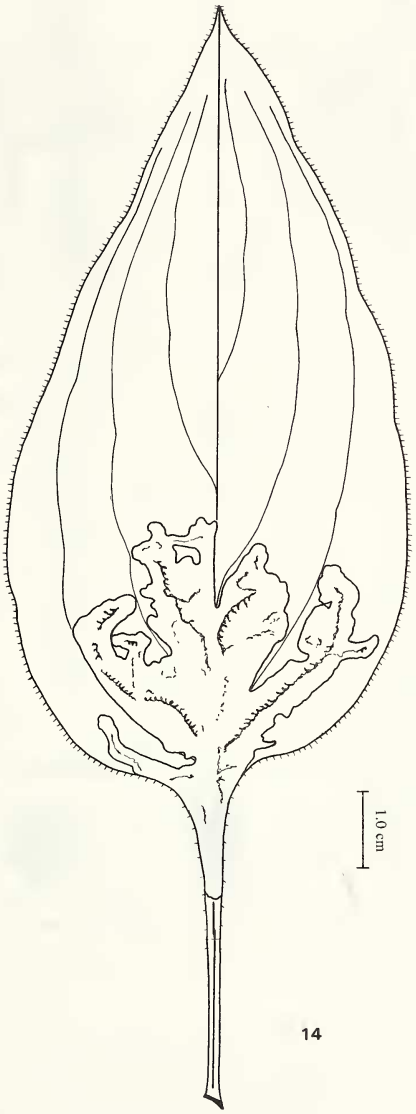

Fig. 14. Leaf of *Mertensia paniculata* (Ait.) with mine of *Phytomyza petiolaris* n. sp.

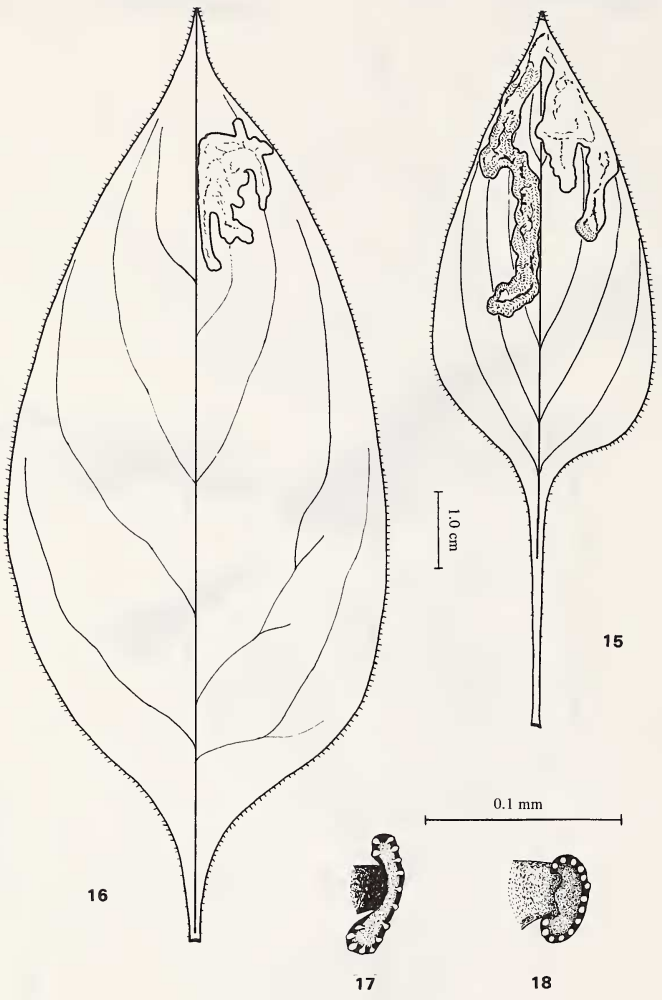

Fig. 15-16. Leaves of *Mertensia paniculata* (Ait.) with mines of: 15, *Phytomyza ovalis* n. sp.; 16, *Phytomyza beringiana* n. sp. Fig. 17. *Phytomyza beringiana* n. sp., right posterior spiracle of puparium in caudal view. Fig. 18. *Phytomyza ovalis* n. sp. (Lake Teslin, Yukon), right posterior spiracle of puparium in caudal view.